Through new eyes: Gaze analysis of Parkinson disease patients performing the Symbol Digit Modalities Test

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Introduction

In pure oculomotor laboratory tasks, latency in volitional tasks is usually prolonged in Parkinson's disease, particularly as cognitive status worsens[1]. We have, however, also found that latencies can become markedly anticipatory relative to controls in response to multi-step rhythmical sequences[1]. This may be in compensation for the marked parkinsonian hypometria which occurs in such volitional tasks, requiring multiple saccades to reach the target.

Do similar anticipatory compensations also occur in attention-demanding tasks? We assessed the differences in eye movements of two groups of Parkinson disease patients as compared with a matched control group.

This trial was conducted as a part of a larger study assessing eye movements in patients with Parkinson disease performing a number of neuropsychological tasks. These include cognitive tasks such as the Montreal Cognitive Assessment, Matrix Reasoning, Map Search and Where's Wally?™ as well as a tea-making task exemplifying a real-world activity.

The Symbol Digit Modalities Test (SDMT)[2] is a symbol substitution test that predominantly examines complex and sustained attention. We examined the differences in oculomotor behaviour in Parkinson disease patients and healthy controls in an attempt to better understand each group's patterns of performance and impairment.

Methods

Data were obtained from 12 patients with Parkinson disease and normal cognition (PD-N), 11 patients with mild cognitive impairment (PD-MCI) and 13 controls matched for age (± 5 years), sex, education (± 2 years) and handedness. All participants spoke English as their first language. Eye movements were recorded monocularly with the mobile video-based iViewX™ HED system (SMI, Berlin, Germany) at a sampling rate of 200 Hz.

Participants were asked to complete a paper-form of the SDMT (see Figure 1 for an example). The paper was rested on a wooden board angled at 60º, about an arm's length away from the participant. Analysis was limited to the first 90 seconds of collected data.

Eye movements were recorded as the participant underwent the task. This resulted in the simultaneous recording of a "scene view" and an "ocular view" (i.e., exact gaze position).

Figure 1. The guiding key, followed by rows of empty boxes to be filled by participants completing the task.

Results

Participant characteristics

	NC	PD-N	PD-MCI
Age (years)	69.5 ± 9.4	66.4 ± 9.3	69.3 ± 10.2
Male/female	12/1	9/3	8/3
Education (years)	13.2 ± 3.3	13.9 ± 3.2	12.6 ± 2.3
Years since diagnosis	N/A	8.1	7
UPDRS-III (motor scale)	N/A	35.4 ± 12.1	36.5 ± 10.8
Hoehn and Yahr stage	N/A	2.1 ± 0.7	2.1 ± 0.6

N/A = not applicable; UPDRS = unified Parkinson's disease rating scale.

SDMT scores

Scores for the $SDMT_1$ task ($F_{2,35}$ = 4.0) were significantly lower in PD-MCI patients (25.8 ± 4.9) compared with PD-N patients (33.4 ± 7.5, p = 0.04) and NC participants (35.4 ± 11.5, p = 0.01). See the figures.

Eye movement parameters

There was no difference among the groups' mean duration of fixations, number of fixations, location-specific fixation numbers or saccade amplitudes.

Discussion

- PD-MCI participants scored significantly lower than NC and PD-N participants. Eye-movement parameters were similar among the study participants, and were not correlated with task performance.
- This is in contrast to findings of significant eye movement differences between patients with schizophrenia and healthy controls completing a computerised version of the oral SDMT[3].
- The mean SDMT score of the PD-N group was similar to that of the NC group, indicating comparable performance on the SDMT, despite PD-related motor deficits.
- Performance on the SDMT significantly improved—as defined by an increase in the trial-score—in participants from all study groups.
- We posit that the Key is used as 'external memory' during the SDMT.
- This fits in part with previous findings on a computerised version of the SDMT[4]. Working memory could be employed to learn symbol-digit pairs during the test, but perhaps due to the time-constrained nature of the test, saccadic eye movements to the Key Area appear to be favoured as the optimal strategy.

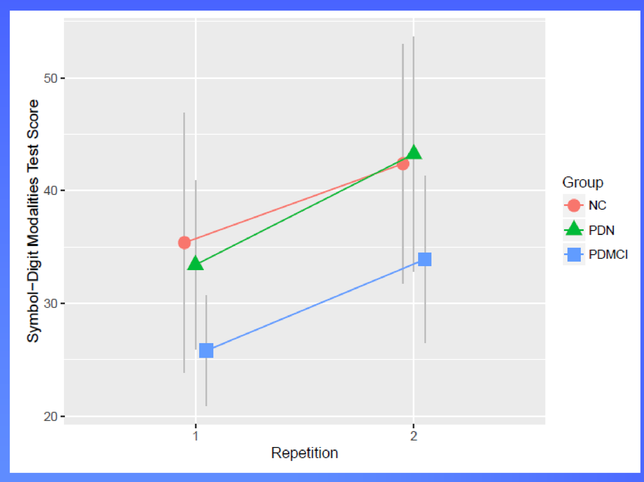

Figure 2. The per-group score improvement between $SDMT_1$ and $SDMT_2$ trials: NC participants' scores improved by a mean of 7 points, PD-N participants' by 9.8 points and PD-MCI participants' by 8.9 points. Error bars represent one standard deviation above and below the group mean.

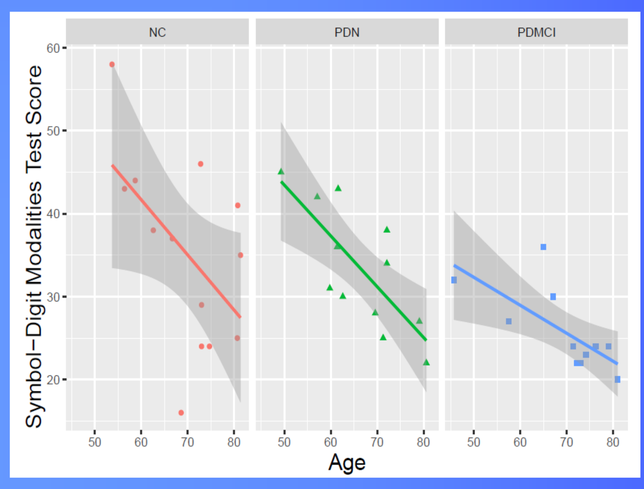

Figure 3. The overall significant negative correlation between age and mean SDMT scores was also found within each group.

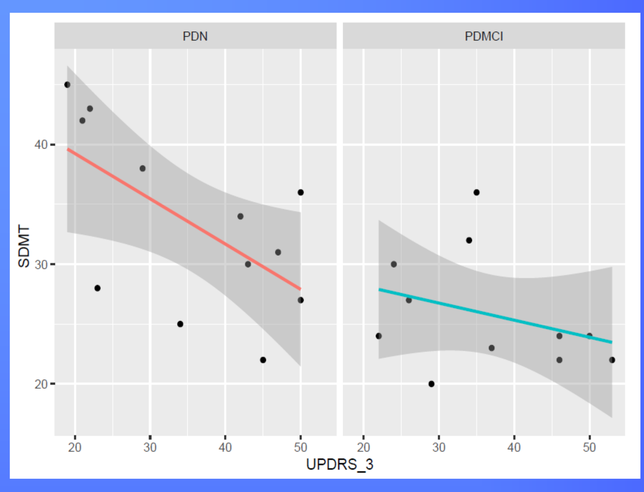

Figure 4. There was an overall negative correlation between UPDRS-III scores and SDMT scores. When examined within groups, the correlation was not pronounced in the PD-MCI group.

References

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